Standard Test Method for Density of Hydraulic Cement[1]

This standard is issued under the fixed designation C188; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This test method covers the determination of the density of hydraulic cement. Its particular usefulness is in connection with the design and control of concrete mixtures.

1.2 The density of hydraulic cement is defined as the mass of a unit volume of the solids.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 **Warning**—Fresh hydraulic cementitious mixtures are caustic and may cause chemical burns to skin and tissue upon prolonged exposure.[2]

1.5 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

C114 Test Methods for Chemical Analysis of Hydraulic Cement
C125 Terminology Relating to Concrete and Concrete Aggregates
C604 Test Method for True Specific Gravity of Refractory Materials by Gas-Comparison Pycnometer
C670 Practice for Preparing Precision and Bias Statements for Test Methods for Construction Materials
D2638 Test Method for Real Density of Calcined Petroleum Coke by Helium Pycnometer

3. Terminology

3.1 *Definitions*—For definitions of terms used in this test method, refer to Terminology C125.

4. Significance and Use

4.1 This test method provides a procedure for the determination of density of hydraulic cement samples using non-instrumental techniques.

5. Apparatus

5.1 *Le Chatelier flask*—The standard flask, which is circular in cross section, with shape and dimensions conforming essentially to Fig. 1 (Note). The requirements in regard to tolerance, inscription and length, spacing, and uniformity of graduation will be rigidly observed. There shall be a space of at least 10 mm between the highest graduation mark and the lowest point of grinding for the glass stopper.

5.1.1 The material of construction shall be excellent quality glass, transparent and free of striae. The glass shall be chemically resistant and shall have small thermal hysteresis. The flasks shall be thoroughly annealed before being graduated. They shall be of sufficient thickness to ensure reasonable resistance to breakage.

5.1.2 The neck shall be graduated from 0 to 1 mL and from 18 to 24 mL in 0.1-mL graduations. The error of any indicated capacity shall not be greater than 0.05 mL.

5.1.3 Each flask shall bear a permanent identification number and the stopper, if not interchangeably ground, shall bear the same number. Interchangeable ground-glass parts shall be marked on both members with the standard-taper symbol, followed by the size designation. The standard temperature shall be indicated, and the unit of capacity shall be shown by the letters "mL" placed above the highest graduation mark.

5.2 Kerosine, free of water, or naphtha, having a density greater than 0.73 g/mL at 23 ± 2°C shall be used in the density determination.

[1] This test method is under the jurisdiction of ASTM Committee C01 on Cement and is the direct responsibility of Subcommittee C01.25 on Fineness.

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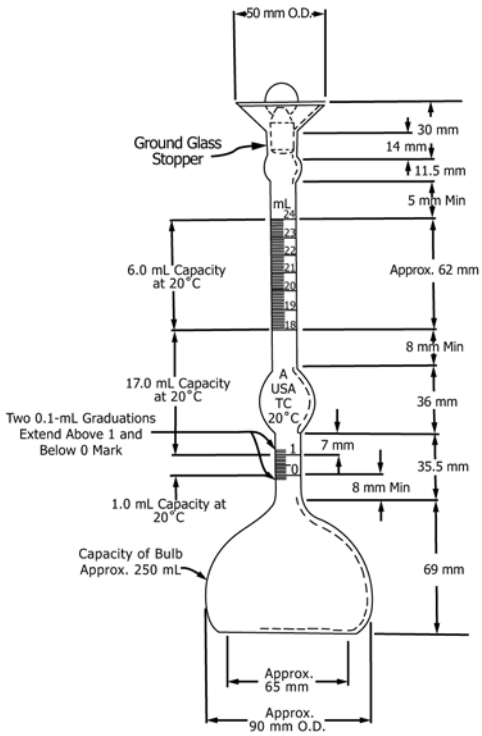
[2] Section on Safety, Manual of Cement Testing, *Annual Book of ASTM Standards*, Vol. 04.01.

[3] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**



NOTE—Variations of a few millimetres in such dimensions as total height of flask, diameter of base, and so forth, are to be expected and will not be considered sufficient cause for rejection. The dimensions of the flask shown in Fig. 1 apply only to new flasks and not to flasks in use which meet the other requirements of this test method.

FIG. 1 Le Chatelier Flask for Density Test

5.3 The use of alternative equipment or methods for determining density is permitted provided that a single operator can obtain results within ±0.03 g/cm^3 of the results obtained using the flask method.

NOTE 1—The design is intended to ensure complete drainage of the flask when emptied, and stability of standing on a level surface, as well as accuracy and precision of reading.

5.3.1 The following alternative methods using helium for density determination are permitted:

5.3.1.1 The methodology as described in Test Method C604. Sections of the standard relating to grinding the sample shall be omitted because cement is already a powder.

5.3.1.2 The methodology as described in Test Method D2638. Sections of the standard relating to grinding the sample shall be omitted because cement is already a powder.

6. Procedure

6.1 Determine the density of cement on the material as received, unless otherwise specified. If the density determination on a loss-free sample is required, first ignite the sample as described in the loss on ignition section on Portland Cement of Test Methods C114.

6.2 Fill the flask (Note 2) with either of the liquids specified in 5.2 to a point on the stem between the 0 and the 1-mL mark. Dry the inside of the flask above the level of the liquid, if necessary, after pouring. Weigh the flask, containing the liquid, and record the mass, M_a, to the nearest 0.05 g. Record the first reading of liquid height after the flask has been immersed in the water bath (Note 3) in accordance with 6.4.

NOTE 2—It is advisable to use a rubber pad on the table top when filling or rolling the flask.

NOTE 3—Before the cement has been added to the flask, a loose-fitting, lead-ring weight around the stem of the flask will be helpful in holding the flask in an upright position in the water bath, or the flask may be held in the water bath by a buret clamp.

6.3 Introduce a quantity of cement in small increments at the same temperature as the liquid (Note 2) sufficient to bring the liquid level in its final position to some point within the upper series of graduation (Note 4). Take care to avoid splashing and see that the cement does not adhere to the inside of the flask above the liquid (Note 5). A vibrating apparatus may be used to accelerate the introduction of the cement into the flask and to prevent the cement from sticking to the neck. After all the cement has been introduced, weigh the flask again to the nearest 0.05 g and record the mass, M_t. Then, place the stopper in the flask and roll the flask in an inclined position (Note 2), or gently whirl it in a horizontal circle, so as to free entrapped air from the cement until no further air bubbles rise to the surface of the liquid. Take the final reading after the flask has been immersed in the water bath in accordance with 6.4.

NOTE 4—The amount of cement required will typically be about 64 g for Portland cement, and somewhat less for other types of cements.

NOTE 5—Using funnels to introduce the powder can help in ensuring that all particles are introduced without spillage while minimizing their adherence to the top inside portion of the flask.

6.4 Immerse the flask in a constant-temperature water bath for sufficient periods of time in order to avoid flask temperature variations greater than 0.2°C between the initial and the final readings.

7. Calculation

7.1 The difference between the first and the final readings represents the volume of liquid displaced by the mass of cement used in the test.

7.2 Calculation of the cement density:

7.2.1 Calculate the mass of cement used in testing, M_c:

$$M_c = M_t - M_a \tag{1}$$

Where:

M_c = Mass of cement used, g,
M_t = Mass of the flask, g, containing the liquid and the cement (see 6.3), and
M_a = Mass of the flask, g, with the liquid to the first set of graduation (see 6.2).

7.2.2 Calculate the cement density, ρ, as follows:

$$\rho = M_c/V$$

where:

ρ = density of cement, g/cm^3,
M_c = mass of cement as calculated under 7.2.1, g, and
V = displaced volume of liquid, cm^3.

NOTE 6—The displaced volume in millilitres is numerically equal to the displaced volume in cubic centimetres.

NOTE 7—Calculate the cement density, ρ, to three decimal places and round to the nearest 0.01 g/cm^3.

NOTE 8—In connection with proportioning and control of concrete mixtures, density may be more usefully expressed as specific gravity, the latter being a dimensionless number. Calculate the specific gravity (sp gr) as follows:

sp gr = cement density/water density at 4°C
(where the density of water at 4°C 1 g/cm^3).

8. Precision and Bias

8.1 The single-operator standard deviation for portland cements has been found to be 0.012.[4] Therefore, the results of two properly conducted tests by the same operator on the same material should not differ by more than 0.03.

8.2 The multilaboratory standard deviation for portland cements has been found to be 0.037.[4] Therefore, the results of two properly conducted tests from two different laboratories on samples of the same cement should not differ by more than 0.10.[4]

8.3 Since there is no accepted reference material suitable for determining any bias that might be associated with this test method, no statement on bias is being made.

9. Keywords

9.1 density; hydraulic cement; specific gravity

[4] These numbers represent the 1s and d2s limits described in Practice C670.

SUMMARY OF CHANGES

Committee C01 has identified the location of selected changes to this standard since the last issue (C188 – 15) that may impact the use of this standard. (Approved Dec. 15, 2016.)

(1) Added 5.3.1 – 5.3.1.2.

Committee C01 has identified the location of selected changes to this standard since the last issue (C188 – 14) that may impact the use of this standard. (Approved Oct. 1, 2015.)

(1) Revised 6.2, 6.3, and 7.2.

(2) Added Notes 4 and 5, and 7.2.1 and 7.2.2.

Committee C01 has identified the location of selected changes to this standard since the last issue (C188–09) that may impact the use of this standard. (Approved July 1, 2014.)

(1) Added 1.5, Sections 3 and 4.

(2) Revised 5.3, 7.2, and Note 6.